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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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EXAMINER	
RUGGLES, JOHN S	

ART UNIT	PAPER NUMBER
1756	

DATE MAILED: 09/01/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/810,385	LU ET AL.	
	Examiner	Art Unit	
	John Ruggles	1756	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *8/5/04 & 3/26/04*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-23* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-23* is/are rejected.

7)☒ Claim(s) *1-23* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *26 March 2004* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *3/26/04*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Information Disclosure Statement

The information disclosure statement (IDS) submitted on 3/26/04 having 5 sheets has been considered. Changes have been made to update information for this application at the top of each sheet, as indicated by the initialed and signed copy of this IDS attached to this Office action.

Drawings

The drawings are objected to because: (1) "FIGs. 5A and 5B" described in the specification at paragraph [0023] line 3 were not found in any of the drawing sheets 1-7 of 7 (which can be corrected by simply changing this reference in the specification to --FIG[[s]]. ~~5A and 5B~~ 5--, in order to correspond with this latter figure number found on drawing sheet 3 of 7) and (2) in Figures 5 and 8, the aerial intensity and near field phase graphs have different horizontal distance coordinates that do not fully correspond with each other in the same figure (it is also noted that no actual dimensions are given for the distance in these figures that would allow comparison with the exemplary defect pit width of 2400nm found at [0022] line 2). Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the

drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

(3) Figures 1-3 and 5 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated (since (a) the corresponding brief description of Figures 1-3 in paragraph [0011] indicate that these drawings "illustrate conventional photomask damage repair methods" and (b) the corresponding description of "FIGs. 5A and 5B" in [0023] indicate that the --FIG[[s]]. ~~5A and 5B~~ 5-- illustrations of (computed) aerial intensity and near field phase are given by using "conventional simulation tools known in the industry"). See MPEP § 608.02(g). Corrected drawings in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Specification

35 U.S.C. 112, first paragraph, requires the specification to be written in "full, clear, concise, and exact terms." The specification is replete with terms, which are not clear, concise and exact. The specification should be revised carefully in order to comply with 35 U.S.C. 112,

first paragraph. Examples of some unclear, inexact or verbose terms used in the specification are: (1) at paragraph [0003] line 2, "it consists of" should be changed to --[[it]] the lithography mask consists of--, in accordance with [0003] line 1; (2) at [0004] line 1, "As IC device becomes" should be corrected to --As IC devices become[[s]]--, in accordance with the plural form of "these devices" found at [0004] line 3; (3) in the brief description of Figure 5 at [0013] lines 2-3, "in accordance with one example of the present disclosure" should be changed (to e.g., [[in]] ~~accordance with one example of the present disclosure~~ using conventional simulation tools, etc., in accordance with [0023] line 1); and (4) at [0029] line 5, the validity of the expression given as "$f=(1-s)/\Lambda$" is questioned as to whether or not Applicants may have actually meant -- ~~$f=(1-s)/\Lambda$~~ $f=1-(s/\Lambda)$-- so that for an exemplary groove space or width s of 16nm (see [0030] lines 7-8) and a grating pitch Λ of 32nm, the fill-factor $f = 0.5$, as indicated for the line marked with diamonds (♦) in Figure 6. Note that due to the number of errors, those listed here are merely *examples* of the corrections needed and do *not* represent an exhaustive list thereof.

Appropriate correction is required. An amendment filed making all appropriate corrections must be accompanied by a statement that the amendment contains no new matter and also by a brief description specifically pointing out which portion of the original specification provides support for each of these corrections.

Claim Objections

Claims 1-23 are objected to because of the following informalities: (1) (a) in claim 1 lines 10-11, (b) in claim 11 lines 12-13, and (c) in claim 20 lines 10-11, the phrases "undesired image printing" should be changed to --an undesired image printing problem-- at each occurrence, in order to better correspond with the latter phrases recited in claim 4 line 3, in claim

14 line 3, and in claim 21 line 3, respectively; and (2) (a) in claim 7 line 1 and (b) in claim 17 line 1, each occurrence of "pitch and" should be corrected to --[[pitch]] pitch, and--, in order to better correspond with claim 6 line 2 (on which claim 7 depends) and claim 16 line 2 (on which claim 17 depends), respectively. Claims 2-10 depend on claim 1, claims 12-19 depend on claim 11, and claims 21-23 depend on claim 20. Appropriate correction is required.

Claim Rejections - 35 USC § 112

Claims 1-23 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention.

(1) (a) In claim 1 line 6, (b) in claim 11 line 8, and (c) in claim 20 line 6, the phrases "the grating repair specification" (singular) lack proper antecedent basis and it is also unclear to which of the one or more grating repair specifications (plural) in claim 1 line 3, in claim 11 line 5, and in claim 20 line 5, respectively, that the above phrases in claim 1 line 6, in claim 11 line 8, and in claim 20 line 6 are each meant to refer. However, for the purpose of this Office action and in order to advance the prosecution of this application, the above phrases (1) (a)-(c) have each been interpreted to mean --the one or more grating repair specifications--. Claims 2-10 depend on claim 1, claims 12-19 depend on claim 11, and claims 21-23 depend on claim 20.

Also, (2) (a) in claim 1 lines 7 and 9, (b) in claim 4 line 5, (c) in claim 11 lines 9 and 11, (d) in claim 14 line 5, (e) in claim 20 lines 7 and 9, and (f) in claim 21 line 5, the phrases "the artificial grating areas" (plural only) each lack proper antecedent basis corresponding to the **one or more** artificial grating areas (emphasis added) previously recited in claim 1 line 5 (on which claim 4 depends), in claim 11 line 7 (on which claim 14 depends), and in claim 20 line 5 (on

which claim 21 depends). However, for the purpose of this Office action each of the above phrases at (2) (a)-(f) have been interpreted to mean --the one or more artificial grating areas--, in accordance with claim 1 line 5, claim 11 line 7, and claim 20 line 5. Claims 2-10 depend on claim 1, claims 5-8 depend on claim 4, claims 12-19 depend on claim 11, claims 15-18 depend on claim 14, claims 21-23 depend on claim 20, and claim 22 depends on claim 21.

Similarly, (3) (a) in claim 6 lines 2 and 3, (b) in claim 8 line 2, (c) in claim 16 line 2 and 3, (d) in claim 18 line 2, and (e) in claim 22 lines 2 and 3, the phrases "the artificial grating area" (singular only, in claim 6 line 2, claim 8 line 2, in claim 16 line 2, in claim 18 line 2, and in claim 22 line 2) and the phrases "the grating area" (singular only, in claim 6 line 3, in claim 8 line 2, in claim 16 line 3, in claim 18 line 2, and in claim 22 line 3) each lack proper antecedent basis corresponding to the **one or more** artificial grating areas (singular or plural, emphasis added) previously recited in claim 1 line 5 (on which claim 6 and claim 8 each depend via claim 4), in claim 11 line 7 (on which claim 16 and claim 18 each depend via claim 14), and in claim 20 line 5 (on which claim 22 depends via claim 21), respectively. But for the purpose of this Office action, the above phrases in claim 6 line 2, in claim 8 line 2, in claim 16 line 2, in claim 18 line 2, and in claim 22 line 2 have each been interpreted to mean --the one or more artificial grating areas-- and the above phrases in claim 6 line 3, in claim 8 line 2, in claim 16 line 3, in claim 18 line 2, and in claim 22 line 3 have each been interpreted to mean --the one or more artificial grating areas--, in accordance with claim 1 line 5, claim 11 line 7, and claim 20 line 5.

(4) In claim 4 line 1, it is unclear whether the step of "determining one or more grating repair specifications" is the same or different from such a step in claim 1 line 3 (on which claim 4 depends). However, for the purpose of this Office action, the above step in claim 4 line 1 has

been interpreted as --the determining one or more grating repair specifications-- to mean the same step as earlier recited in claim 1 line 3. Claims 5-8 depend on claim 4.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lin (US 2004/0191642) in view of either Tazawa et al. (US 5,282,140), Iwasaki et al. (US 2002/0058188) or Smith (US 2003/0207184), and further in view of Tejnil (US 2004/0234869) and Lalanne et al. (The Optical Properties of Artificial Media Structured at a Subwavelength Scale [Document CH in the 3/26/04 IDS, Pages 1-11]).

Lin teaches a method for repairing a photomask or mask having a void or pit defect in a transparent substrate (e.g., of quartz, etc., [0030]) by etching progressive steps in the substrate to enhance transmittance of the substrate (abstract). Figure 3 shows a mask having a transparent substrate 10′ with an actual void defect 11′, but the defect can be either a protrusion defect or a void defect [0034]. Figures 4 and 5 show side and plan views, respectively, of a repaired mask in which the transparent substrate 10″ has a stepped aperture 14 that eliminates the previous actual void defect 11′ [0038], [0040]-[0041]. The width of each plateau or step is about 1.0 micron for an exposure light wavelength of 193nm or 248nm [0042]. The difference in phase shift (PS) or depth between directly adjacent steps, plateaus, or areas can be adjusted (at desired intervals of e.g., 45°, 60°, 90°, 120°, etc. [0043]-[0045]) to obtain a fairly uniform transmitted

light intensity across the stepped regions of the repaired mask substrate for uniform exposure of a photoresist layer through the repaired mask [0046] (which is understood to mean that any undesired image printing problem that would have been caused by the mask defect without repair is avoided).

Lin does not specifically teach: ***[1]*** determining topographical information about the mask defect; ***[2]*** determining mask repair specifications based on an optical simulation using the topographical information about the mask defect; and ***[3]*** that the areas etched into the mask substrate to repair the defect form one or more artificial grating areas so that each grating area is no wider than the exposure wavelength to change the effective refractive index of a localized area encompassing the defect.

However, three-dimensional (3-D) topological or topographical information analysis and optical simulation of a workpiece area that includes defining a numerical mesh over the workpiece surface (e.g., encompassing a surface defect on a shadow mask to determine repair specifications, etc.) before deposition or etching (e.g., to repair the surface defect, etc.) related to lithography for manufacturing integrated circuits has been known for some time in the art of semiconductor device manufacturing as having the benefits of reducing design times, experimentation, and manufacturing costs (as taught by Tazawa et al., abstract, c1/L8-28). Similarly, Iwasaki et al. teach (3-D, topographical) optical simulation of a (single trench) Levenson phase shift mask (alt-PSM) having PS trench(es) in the substrate for successfully directly analyzing defect(s) by comparing transmission of incident light intensities between the PS and non-PS regions of the PSM (e.g., using a CCD camera, etc.) before repairing or correcting the defect (title, abstract, [0103]). Also, Smith teaches a method and apparatus for

correcting or repairing PS defects (e.g., bump defects, etc.) in an alt-PSM by scanning for location of defects, 3-D analysis of the defects, and focused ion beam (FIB) treatment controlled by an etch map (or repair specifications) generated based on the 3-D results to eliminate the PS defects (title, abstract, front page Figure 12, etc.). As shown in Figures 9, 12, and 13, the alt-PSM 120 includes a mask substrate of silica, quartz, calcium fluoride (CaF_2, which is understood to be suitable for either 193nm, 157nm, or even shorter exposure wavelengths), or other well known suitable transparent material [0037]. The 3-D analysis of the mask defect can be carried out, for example, by an atomic force microscope (AFM) [0041] *([1], [2])*.

Tejnil teaches that closely spaced sub-wavelength width structures or grooves (in a grating pattern) etched into a transparent mask substrate at a step height or depth to produce an effective PS (of e.g., 60° to 120°, etc.) that is different from the PS (of e.g., 180°, etc.) normally associated with substrate trenches or grooves having a width greater than the wavelength of exposure light, but still having the same step height or depth (abstract, [0015]). As shown in Figure 5, the sub-wavelength etched features 400 in the mask substrate may be significantly smaller than the wavelength (λ) of incident light (e.g., $x_1 \approx x_2 < \sim \lambda/2$, etc. [0015]). An exemplary exposure wavelength is 193nm [0019]-[0020]. This sub-wavelength grating pattern of grooves in the mask substrate producing an effective PS of 60° to 120° can be etched at the same depth as wider grooves producing a PS of 180° using fewer processing steps and at a lower cost than by separately patterning and etching features or steps in the mask substrate to depths corresponding to a PS of 60° to 120° [0021].

Lalanne et al. teach that introduction of very fine structures into a standard transparent material (e.g., as a transparent base or substrate of a known refractive index having a series of

holes, etc.) with a scale that is substantially smaller than the wavelength of light incident on the transparent substrate material (having sub-wavelength holes or grooves), the very fine sub-wavelength structures will not be resolved by the incident light transmitted through the transparent substrate, but instead the light "sees" a composite material having optical properties (such as an effective refractive index) between those of air and those of the solid transparent substrate material. By varying the fraction of material that is removed or etched to form the sub-wavelength holes or grooves, it is possible to control the effective refractive index of the transparent substrate material (page 1, Introduction section, right col.). A regularly spaced series of sub-wavelength parallel grooves would form a periodic grating called an "artificial" media (page 2, left col.). Computation plays a crucial role in the analysis and design of periodic artificial media (such an artificial grating of sub-wavelength grooves in a transparent substrate), with Fourier expansion techniques being applicable to any periodic microgeometry (page 3, right col.). Sub-wavelength gratings are characterized by fill factor (f, which represents the fraction of high-index transparent substrate material in the remainder of low-index air-filled grooves in the overall grating area, page 3, left col.) and period or spacing (page 4, left col. to page 5, right col.). By controlling the structure of the sub-wavelength gratings or other structures in a transparent substrate, the resulting range of optical properties (e.g., effective refractive index, etc.) can be extended for increased optical design possibilities (page 9, Conclusion section, right col. *[3]*).

It would have been obvious to one of ordinary skill in the art at the time of the invention in the method of repairing a mask substrate void or pit defect by etching steps at desired PS depths or step heights (having PS intervals of e.g., 45°, 60°, 90°, 120°, etc.) for uniform exposure

of a photoresist layer through the repaired mask (as taught by Lin) to include 3-D topological or topographical information analysis and optical simulation of a mask defect before etching (e.g., to repair the surface defect, etc.), because 3-D topographical information analysis and optical simulation of workpiece surfaces (e.g., to detect a surface defect, etc.) related to lithography for manufacturing integrated circuits have been known for some time as having the benefits of reducing design times, experimentation, and manufacturing costs (as taught by either Tazawa et al., Iwasaki et al., or Smith *[1]*, *[2]*). It would also have been obvious to alternatively form sub-wavelength artificial grating areas etched in the mask substrate adjacent to the void or pit defect so that the etched artificial grating areas have desired effective PS intervals (of e.g., 45°, 60° to 120°, etc., as taught by Tejnil) and also exhibit a desired effective refractive index, because (1) this grating pattern of sub-wavelength etched grooves in the mask substrate can be etched at the same depth as wider grooves producing a PS of 180° using fewer processing steps and at a lower cost than by separately patterning and etching features or steps in the mask substrate to depths normally corresponding to the desired PS intervals (of e.g., 45°, 60° to 120°, etc., as taught by Tejnil); and also because controlling the structure of the sub-wavelength grating pattern in the mask substrate extends the resulting range of optical properties (e.g., effective refractive index, etc.) for increased optical design possibilities (as taught by Lalanne et al. *[3]*).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Ruggles whose telephone number is 571-272-1390. The examiner can normally be reached on Monday-Thursday and alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on 571-272-1385. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

jsr